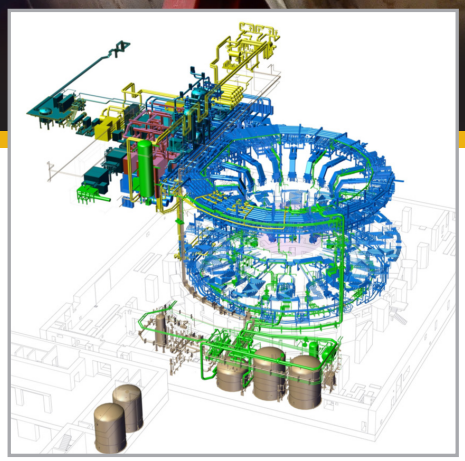
Tokamak Cooling Water System

Drain tanks for the tokamak cooling water system are in storage at the ITER site, ready for installation. Photo: ITER Organization



Tokamak cooling water system design. Image: US ITER

Drain tank during leak testing at Joseph Oat Corporation. Photo: US ITER

US Contribution

The US is responsible for the design, fabrication, acceptance testing, and delivery of the Tokamak Cooling Water System (TCWS).

Overview

The TCWS, the primary cooling system, has the capacity to remove 1 GW of heat from client systems and transfer the heat using major industrial equipment through the distribution system to an interface with India's scope: the secondary cooling system. The TCWS is designed to cool client systems, such as the first-wall/blanket, vacuum vessel, divertor, and neutral beam injector. Supporting operations are designed to meet functional requirements, including baking of in-vessel components, chemical and volume control of water provided to client systems, draining and drying for maintenance, and support for leak detection/localization. The TCWS interfaces with the majority of ITER plant systems, including the steady state electrical supply, plant control systems, radioactive waste, and the tokamak building.

The TCWS is classified as safety important for the confinement of radioactivity. The system is comprised of over 100 major industrial pieces of equipment operating with maximum design temperatures of 400 °C (gas) and maximum pressure of 5 MPa (water @ 240 °C), and must withstand an N16 gamma radiation source in excess of 10^{+17} g/s, an N17 neutron source in excess of 10^{+13} n/s and magnetic fields to 125 millitesla (mT).

1st Plasma Scope

Innovative arrangements with the IO established an entity (IO-TCWS) to complete final system design plus piping deliveries on behalf of the US. These TCWS subsystems are: 36 km (22 miles) of piping to distribute cooling water, vacuum vessel primary heat transfer system, draining and refilling, and drying subsystems.

Status

Five drain tanks were delivered to the ITER site in September 2015. This early delivery met construction sequencing requirements for captive components. Final Design Review of First Plasma hardware was completed in 2017.

Tokamak Cooling Water System

Key Vendors

- ITER Organization (St. Paul-lez-Durance, France)
- IO-TCWS (St. Paul-lez-Durance, France)
- Ansaldo Nucleare S.p.A. (Genoa, Italy)
- Empresarios Agrupados Internacional, S.A. (Madrid, Spain)
- Tata Consultancy Services (Hyderabad, India)
- Senior Flexonics Pathway (New Braunfels, TX)
- Schultz Piping GmbH (Tunica, MS and Krefeld, Germany)
- Joseph Oat Corp. (Camden, NJ)
- Areva Federal Services (Charlotte, NC)

Piping fabrication is underway at Schulz Xtruded Products in Robinsonville, Mississippi. Photo: Schulz

French nuclear-qualified drain tanks fabricated in the United States were delivered to the ITER site in 2015. Photo: ITER Organization

Technical Description

- **Total installed heat removal capacity:** 1,000 MW (thermal)
- **Max coolant operating temperature:** 126 °C (plasma), 240 °C (water baking), 400 °C (gas baking)
- **Max design pressure:** 5.0 MPa
- **Cooling water inventory:** over 1,000,000 L

Equipment includes:

- **Heat Exchangers:** Heat transfer capacities from less than 1 MW to over 200 MW
- **Heaters:** Providing over 9 MWe of heating capacity
- **Compressor:** 3 MW nitrogen compressor to blow out and dry client systems
- **Pumps:** Ranging from small transfer pumps to 3 MW main pumps, with total pumping capacity over 25 MW
- **Normal and Safety Drain Tanks (4):** 231,600 L volume (10 m x 6 m diameter), 73,500 kg dry weight
- **Neutral Beam Injector Drain Tank:** 101,300 L volume (5 m x 6 m diameter), 47,400 kg dry weight
- **Pressurizers (3):** With the largest 66 m^3 Volume, Design Pressure 5.0 MPa
- **Nuclear Grade Piping:** Over 36 km of SS piping, ranging from small bore to DN500
- **Nuclear Grade Valves:** Thousands of valves ranging from small bore to DN500
- **Piping and equipment supports:** Attached to steel plates embedded in concrete

Safety functions:

- **Confinement of radioactivity**
  - Maximum tritium content: 0.32 mg/m^3
  - Maximum activated corrosion products: 6.6 GBq/m^3
- **Removal of decay heat in case of a loss of off-site power**
  - Low flow pump on Class III-Safety power
  - Small heat exchanger on Safety Chilled Water CHWS-H1

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